X-ray micro-tomography at the IMX beamline (LNLS)

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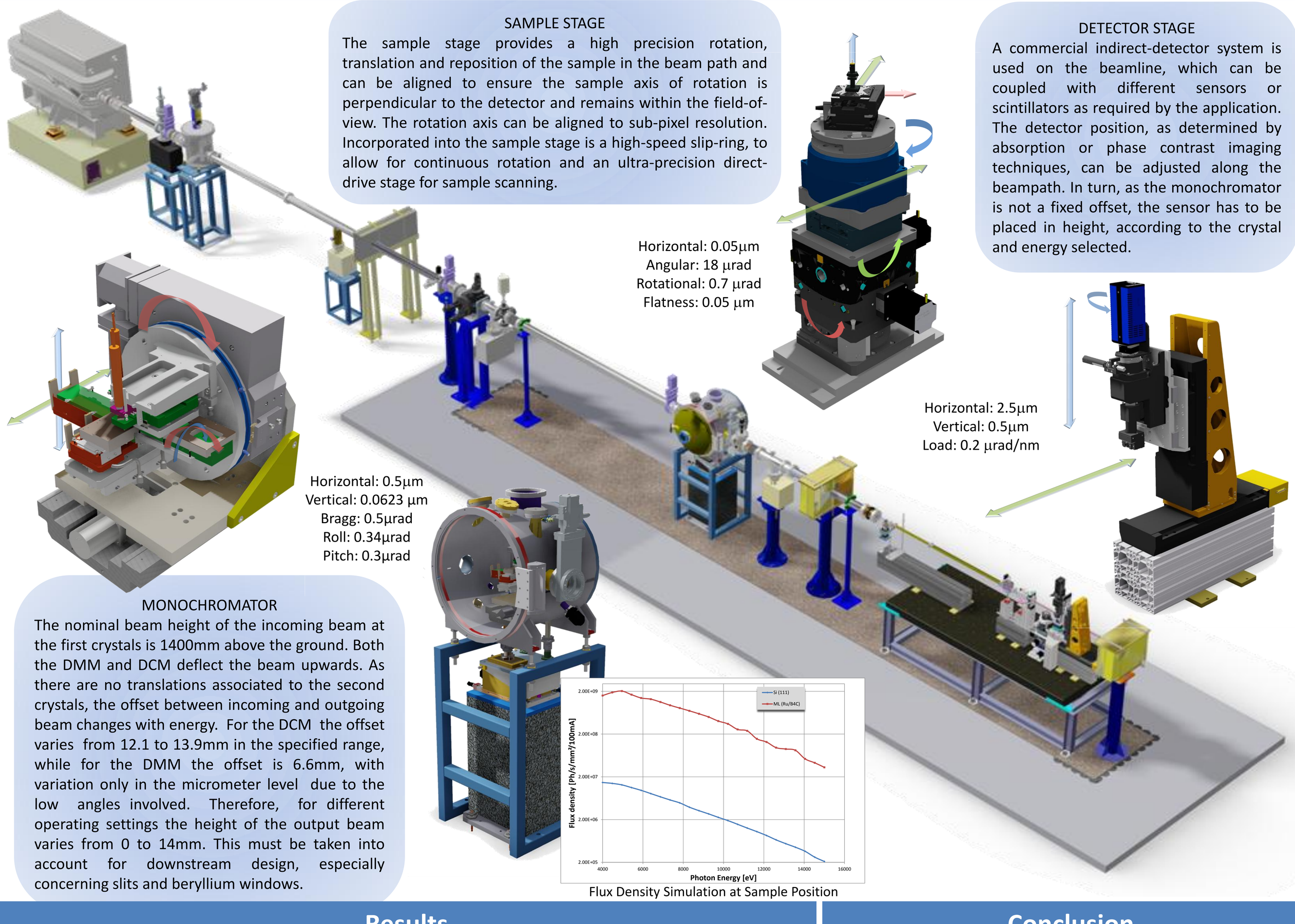
Since the discovery of X-Rays in 1895, they have been used for imaging, especially for radiography. With the introduction of synchrotrons as powerful sources of x-rays, many other imaging techniques, became available. Nowadays imaging beamlines typically acquire images using a combination of absorption, phase or dark field imaging modalities. As is well known, X-rays penetrate all light materials very well and 2D projections of the sample can be taken easily. In tomography, the full 3D information can be obtained by acquiring projection images of the sample along a number of different directions. These projections can be used as input for computerized tomographic reconstruction.

The imaging beamline, IMX, at LNLS extracts synchrotron radiation from bending magnet D6. This beamline can operate in either monochromatic beam or white beam, by removing the crystals from the beam path. The white beam energy spectrum ranges from 4 to 25 keV, with a photon flux at the sample of 10^{14} ph/s. A monochromatic beam ranging between 6keV and 14keV is provided by either a double multilayer monochromator with a photon flux density of around 10^{9} photons/s/mm2 (between 4keV and 14keV) or a double-crystal Silicon (Si111) monochromator with photon flux density of approx 10^{7} photons/s/mm2 (between 4keV and 14keV).

Beamline

SAMPLE STAGE

The sample stage provides a high precision rotation, translation and reposition of the sample in the beam path and can be aligned to ensure the sample axis of rotation is perpendicular to the detector and remains within the field-of-view. The rotation axis can be aligned to sub-pixel resolution. Incorporated into the sample stage is a high-speed slip-ring, to allow for continuous rotation and an ultra-precision direct-drive stage for sample scanning.



Horizontal: 0.05µm
Angular: 18 µrad
Rotational: 0.7 µrad
Flatness: 0.05 µm

DETECTOR STAGE

A commercial indirect-detector system is used on the beamline, which can be coupled with different sensors or scintillators as required by the application. The detector position, as determined by absorption or phase contrast imaging techniques, can be adjusted along the beampath. In turn, as the monochromator is not a fixed offset, the sensor has to be placed in height, according to the crystal and energy selected.

Horizontal: 2.5µm
Vertical: 0.5µm
Load: 0.2 µrad/nm

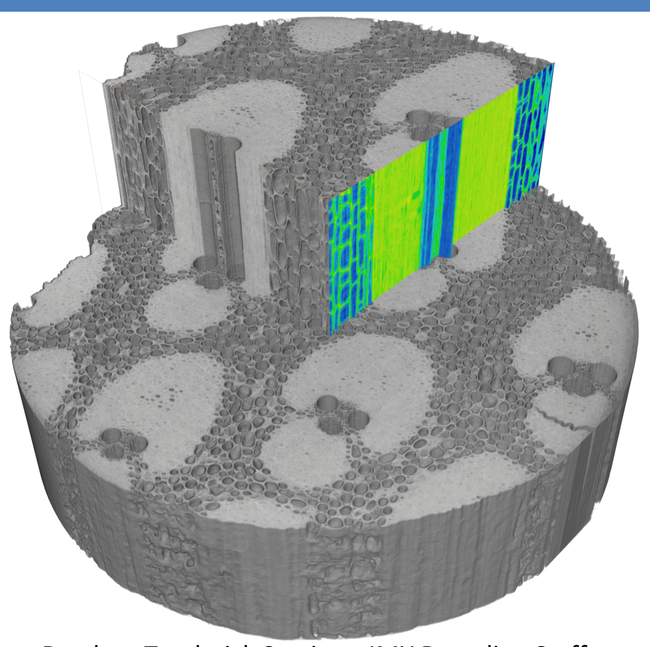
Horizontal: 0.5µm
Vertical: 0.0623 µm
Bragg: 0.5µrad
Roll: 0.34µrad
Pitch: 0.3µrad

MONOCHROMATOR

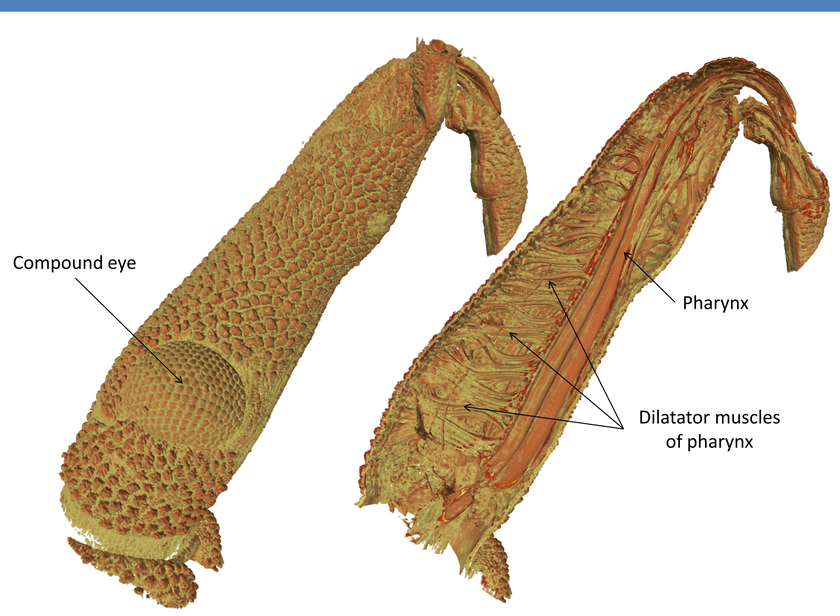
The nominal beam height of the incoming beam at the first crystals is 1400mm above the ground. Both the DMM and DCM deflect the beam upwards. As there are no translations associated to the second crystals, the offset between incoming and outgoing beam changes with energy. For the DCM the offset varies from 12.1 to 13.9mm in the specified range, while for the DMM the offset is 6.6mm, with variation only in the micrometer level due to the low angles involved. Therefore, for different operating settings the height of the output beam varies from 0 to 14mm. This must be taken into account for downstream design, especially concerning slits and beryllium windows.

Flux Density Simulation at Sample Position

Results



Bamboo Toothpick Section - IMX Beamline Staff



Rhodnius Prolixus ("Barbeiro") Head - IMX Proposal #16929

Conclusion

A simple and functional micro-tomography beamline is presented. The resolution of the beamline was improved thanks to the use of a monochromatic beam associated to a recently implemented high precision rotate stage. However, due to the beam offset related to the energy change while using monochromatic beam, a precise detector stage must be used and coupled to the beampath. In addition, a high precision rotation stage is now in use and allows the beamline to reach sub-micron resolution which is highly desirable for such kind of experiments.

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